Kaufmann, J. H. (1974): Social ethology of the whiptail wallaby, *Macropus parryi,* in northeastern New South Wales. Anim. Behav. **22**, 281–369.
Langer, P. (1975): Macroscopic anatomy of the stomach of the Hippopotamidae Gray, 1821. Zbl. Vet. Med. C **4**, 334–359.
— (1978): Anatomy of the stomach of the collared peccary, *Dicotyles tajacu* (L., 1758) (Artiodactyla, Mammalia). Z. Säugetierkunde **43**, 42–59.
Moir, R. J.; Somers, M.; Waring, H. (1956): Studies on marsupial nutrition. I. Ruminant-like digestion in a herbivorous marsupial (*Setonix brachyurus* Quoy and Gaimard). Aust. J. biol. Sci. **9**, 293–304.
Mollison, B. C. (1969): Food regurgitation in Bennetts's wallaby, *Protemnodon rufogrisea* (Desmarest) and the scrub wallaby, *Thylogale billardierii* (Desmarest). CSIRO Wildl. Res. **5**, 87–88.
Morton, S. R.; Burton, T. C. (1973): Observations on the behaviour of the macropod marsupial *Thylogale billardierii* in captivity. Aust. Zoologist **18**, 1–14.
Owen, R. (1835): On the anatomy of *Macropus parryi*, Benn. Proc. Zool. Soc. London 1835, 152.
Porzig, E. (1969): Das Verhalten landwirtschaftlicher Nutztiere. Berlin: VEB Deutscher Landwirtschaftsverlag.
Ride, W. D. L. (1959): Mastication and taxonomy in the macropodine skull. In: Function and Taxonomic Importance. No. 3. Hrsg. von A. J. Cain. London: Systematics Assn. Publ. S. 33–59.
Russell, E. (1970): Observations on the behaviour of the red Kangaroo (*Megaleia rufa*) in captivity. Z. Tierpschol. **27**, 385–404.
Schultz, W. (1976): Der Magen-Darm-Kanal der Monotremen und Marsupialier. Handbuch der Zoologie. Hrsg. von J.-G. Helmcke, D. Starck und H. Wermuth. Berlin, New York: De Gruyter. 8. Bd. 53. Lfg. S. 1–117.
Schürer, U. (1973): Verhaltensbeobachtungen am Bennettskänguruh *Macropus rufogriseus fruticus* Ogilby, 1838 mit besonderer Berücksichtigung der Bewegungsweisen. Diplomarbeit, Freie Universität Berlin.
— (1978): Vergleichende Untersuchung des Ruheverhaltens von Känguruhs (Macropodidae). Diss. FU Berlin.
Tyndale-Biscoe, H. (1973): Life of marsupials. London: Edward Arnold.
Ullrich, W. (1961): Zur Biologie und Soziologie der Colobusaffen (*Colobus guereza caudatus* Thomas, 1885). Zool. Garten N. F. **25**, 305–368.

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The reproductive biology of Suncus murinus L. in Rangoon, Burma[1]

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Abstract

Observations on the reproductive biology of *Suncus murinus* in Rangoon, Burma, are described. Males grew to a significantly greater length and weight than females. Maximum weight for males was 110 g; for non-pregnant females, 80 g. Males predominated in the captures by a ratio of 1:0.7.

All males had reached fertility at 52 g body weight and 124 mm head and body length. Sexual maturity in females, as judged by either visible corpora lutea, visible pregnancy or lactation, occurred as early

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as 20 g body weight and 98 mm head and body lenght. The 50% point for pregnancy and/or lactation occurred at 32 g and 108 mm.

Overall, 59% of all adult females were visibly pregnant, and another 10% were lactating but not visibly pregnant, giving 69% showing breeding activity. Of the pregnant animals 26% were also lactating, probable indirect evidence of postpartum conception. Mean litter size was 2.99 ± 1.21 (S.D.). Intrauterine mortality accounted for a loss of 0.87 embryo from the early stage of pregnancy to the late (3.34 to 2.47 mean number of embryos). The corrected litter size of 2.47 was used to calculate production of young which ran 24.2 per breeding female per year.

Prevalence of pregnancy was highest in the cool, dry months of January through March and the hot months of April through June, covering the transition into the monsoon season. The monsoon rains apparently exert a depressing effect on pregnancy and only during the monsoon months were more pregnant females found indoors than outdoors.

Suncus, despite its longer gestation period and smaller litter size, can maintain its populations in relation to the rat species in the urban commensal fauna. It does this, in part, by maintaining a higher prevalence of pregnancy, breeding at an earlier age, and commonly breeding post-partum resulting in a short interval between successive litters. Other factors regarding its role as a scavenging insectivore and the possibility of differential mortality during critical periods are speculated as helping in defining its success in the tropical urban environment.

Introduction

The house or musk-shrew, *Suncus murinus*, is a common commensal small mammal in many places in Southeast Asia, as well as India, Asia Minor, Madagascar, Taiwan, Japan and Guam. Its geographic distribution is generally regarded as having been influenced by man (DE VOS et al. 1956; ELLERMAN and MORRISON-SCOTT 1966; BARBEHENN 1974). It is in close contact with both man and other commensal small mammals over much of its geographic range (HARRISON 1974). This species has only recently been recognized as of probable public health importance in urban areas because of its reported association with plague in Burma, Vietnam and Taiwan (BROOKS et al. 1977; CAVANAUGH et al. 1968; MARSHALL et al. 1967; MCNEIL et al. 1968). It has been implicated as a potential reservoir in other diseases as well. Kyasanur Forest Disease (KFD) virus was isolated from *S. murinus* in India (BOSHELL et al. 1968). It was found infected with *Leptospira* in Malaysia (SMITH et al. 1961), the Philippines and Taiwan (KUNDIN et al. 1970) and Indonesia (VAN PEENEN et al. 1971). Recent unpublished data obtained in Rangoon indicates the possible involvement of *S. murinus* in the epizootiology of murine typhus, and it is an important host for the primary vector of plague, *Xenopsylla cheopis* (WALTON et al. 1978).

In Rangoon, *S. murinus* has been trapped in association with several commensal rodent species: *Rattus rattus, R. norvegicus, R. exulans, Bandicota bengalensis* and *Mus musculus. Suncus murinus* was found to be distributed throughout the city, both indoors and outdoors, and comprised 18% of over 8,000 captures of commensal small mammals. Though generally captured at ground level, some individuals were obtained from the upper floors of offices, flats and houses.

The following observations are based upon data collected by the Rodent Control Demonstration Unit of the World Health Organization in cooperation with the Ministry of Health of the Socialist Republic of the Union of Burma as part of a survey of the small mammal fauna of the city of Rangoon. Since there are few published observations on the reproductive biology of this species in the wild (BARBEHENN 1962; DESHPANDE 1960; HARRISON 1955; LOUCH et al. 1966), the data from Rangoon, Burma, are reported and comparisons made with the previous studies.

Materials and methods

Animals were captured in locally-made wooden live traps, usually baited with dried fish, and brought to the laboratory while still in the traps. There they were anaesthetized, combed for ectoparasites and some were bled by cardiac puncture. Individual shrews were then sexed, weighed and measured. All mea-

surements are given in millimetres and weights in grams. Body weight to the nearest gram was obtaines by means of a Pesola spring scale.

At necropsy, reproductive condition was noted on all females: location and number of visible mammaries, lactation, visible pregnancy and size of embryos, presence of visible corpora lutea and presence of placental scars. From a sample of captured males, testes were removed and weighed to the nearest 10 mg on a torsion balance and the visibility of spermatogenic tubules under 10 x magnification was scored as none, barely visible, visible but not prominent, and prominently visible. Samples were obtained from all months of the year.

Table 1

Mean (±1 SD) body weight and body length in Suncus murinus from Rangoon, Burma

nonpregnant females only were used in calculation of mean body weight

Head and body length size class mm	Males No.	Males Weight g	Females No.	Females Weight g	Probability of difference P =
90– 99	5	30.0 ± 10.9	3	33.3	N. S.
100–109	30	32.0 ± 11,4	28	33.2 ± 10,8	N. S.
110–119	78	44.6 ± 14.7	82	37.5 ± 10.3	N. S.
120–129	209	52.4 ± 12.2	136	43.6 ± 10.5	.01
130–139	393	63.6 ± 11.3	55	46.4 ± 11.4	.01
140–149	245	69.7 ± 10.7	12	48.5 ± 8.6	.01
150–159	39	76.2 ± 11.5	1	42.0	—
160–169	6	74.7 ± 13.0	0	—	—
170–179	2	75.0	0	—	—
Total	1007		317		
Mean body weight, g		60.9 ± 13.7		41.6 ± 11.3	
Maximum body weight, g		110			80 (non-pregnant)
Mean head and body length, mm		133.2 ± 16.7			121.3 ± 9.5

Results

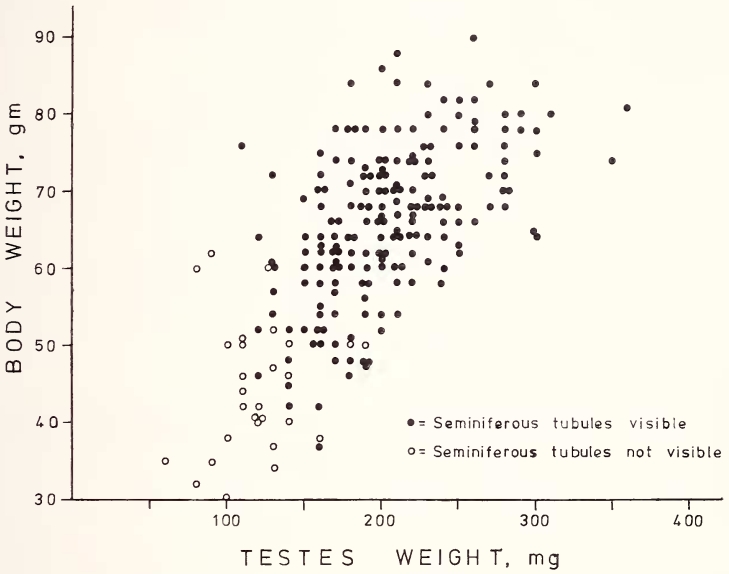
Characteristics of the sample and sex ratio

The characteristics of the sample in terms of head and body length (HBL), body weight (BW) and sex ratio are given in Table 1. A total of 1688 shrews was examined; 1007 males and 681 females. Males grew to a greater body weight and longer body length than females, the differences in body weight being significant in all body lengths exceeding 120 mm (P = .01). Males predominated in the largest length classes. The maximum body weight recorded for males was 110 g; for non-pregnant females, 80 g, and for pregnant females, 90 g. The proportion of males to females in the sample was 1:0.7. This proportion differs significantly from a 1:1 sex ratio ($\chi^2 = 62.9$, P = .001).

Sex maturation

Males: The testes of the musk shrew are retained permanently in the posterior position of the coelomic cavity in shallow evaginations called cremaster sacs (Deshpande 1959). Testes in which seminiferous tubules cannot be seen macroscopically are white or pale yellow. Those with visible but inconspicuous tubules are light green, while those with prominent tubules are a dark pea-green colour (Deshpande 1959; Dryden 1969). The size at sexual maturity of male *S. murinus* from Rangoon, based upon the 50% point in BW at which macroscopically

visible seminiferous tubules were seen in the testes, was 44.5 g. The point at which all males showed evidence of fertility based upon visible tubules in the testes occurred at 52 g BW and a HBL of 124 mm (Fig. 1). At this point and beyond, and at a testis weight of 160 mg, all males were fertile. No other significant correlation was noted between weight of the animal and weight of the testes. Minor seasonal changes in the testes were seen, with lesser weights in the cool season months of December through February and a drop in proportion of fertile males in the fall and winter (Table 2).



The relationship between body weight of male *Suncus murinus* and the weight and condition of the testes

Females: Size at sexual maturity in the female shrew is difficult to assess by the usual rodent criteria of opening of the vaginal orifice (which is concealed in the cloaca) and by visibility of corpora lutea. Because *Suncus murinus* is apparently an induced ovulator (Dryden 1969), corpora lutea would be present only following mating, Dryden (pers. comm.) states that the vaginal canal is open very early, probably at birth. Using the presence of corpora lutea, visible pregnancy and/or lactation, we can but report that one or more of these events were seen in females as small as 98 mm HBL and weighing as little as 20 g. A 50% point was derived for pregnancy and/or lactation; this occurred at 32 g BW and 108 mm HBL. For purposes of distinguishing sexually mature females we have arbitrarily used the body weight class of 20 to 29 g and the length size class of 100–109 mm in this study.

Prevalence of breeding activity

The prevalence of pregnancy was determined from visible uterine swellings or visible embryos. Implantation in *Suncus murinus* takes place on day 7 (Dryden 1969) and the first visible swellings could probably be seen on day 8. Therefore pregnancy can be detected only in 22/30 (73%) of all females that might be pregnant. The figures given in Table 3 are only those visible pregnancies actually observed and no attempt has been made to correct the prevalence of pregnancy. There was a positive relationship between body size of the female (BW or HBL) and the prevalence of pregnancy.

A better indication of overall breeding activity in adult females is to include all lactating, but not visibly pregnant animals. When these are added to the proportion pregnant, the percent of all adult females giving evidence of active breeding is almost 69% (refer to Table 3). Concurrent pregnancy and lactation, an indication of probable post-partum breeding, was seen in 26% of the pregnant females.

Placental scars were seen only in some of the obviously mature or lactating animals and were not useful as a means of assessing past breeding performance. DRYDEN (pers. comm.) says that placental scars form but are not very obvious from external examination; they can be picked up microscopically as hemosiderin deposits. The duration of persistence of placental scars is not known.

Seasonal changes in breeding activity

Over the 26-month period covered by this study pregnant females were found in all months of the year (Table 4). No significant difference was found by month in data from one year to the next so all data for 26 months are pooled to give the yearly pattern. There were only minor fluctuations in the total breeding activity when both pregnancy and lactation were considered, except for the month of December. The difference between the proportion breeding in each quarter of the year, however, was significant ($\chi^2 = 4.51$, $P = .05$). There was an indication that the breeding effort may be bimodal, with a peak in May and another peak in September to November, except for the anomaly of the October data.

Table 2

Seasonal variation in testes weight and fertility in male Suncus murinus

	Winter	Spring	Summer	Fall
Sample size	38	44	58	79
Mean body weight, g	61.7	65.3	62.2	61.7
Mean testes weight mg/g body weight	2.78	3.11	3.14	3.16
(± 1 SD)	± 0.55	± 0.58	± 0.58	± 0.71
Percent fertile	82	93	93	87

Litter size

The mean number of embryos in all pregnant females was determined to be 2.99 ± 1.21 (S. D.), ranging from 1 to 7. Litter size tended to increase with increasing HBL and BW of the female (Table 5). Intrauterine mortality was estimated by noting a decrease in litter size with advancing stages of pregnancy. Such a decrease was seen in Rangoon where the number of embryos in early stages of visible pregnancy (< 7 mm crown-rump length) averaged 3.34 per litter while in late stages (> 15 mm CR) it averaged only 2.47. This represents a loss of 0.87 embryo or a decrease of 26%.

Prevalence of pregnancy by place of capture

A significant number of pregnant females was captured outdoors. When both pregnancy or lactation (all actively breeding females) were analyzed by place of capture (Table 6), a significant proportion was found outdoors ($\chi^2 = 5.44$, $P = .02$). The proportions for non-breeding females, in contrast, did not show any difference between indoor vs. outdoor capture. An analysis of male *Suncus* showed that all sizes were captured in greater numbers outdoors (overall 59% from outdoors).

Table 3

Relationship of head and body length and body weight to reproductive activity in female S. murinus

Head and body length mm	No. examined	Visibly pregnant %	Lactating %	Pregnant or lactating %	Body weight class g	No. examined	Visibly pregnant %	Lactating %	Pregnant or lactating
90– 99	4	25	0	25	20	3	0	0	0
100–109	42	38	14	52	20–29	40	28	2	30
110–119	168	57	7	64	30–39	172	49	8	57
120–129	306	60	13	73	40–49	300	64	10	74
130–139	138	66	6	72	50–59	110	66	17	83
140–149	19	53	5	58	60–69	45	69	7	76
150–159	4	75	0	75	70	10	80	0	80
Number over 100mm in body length and mean percent	677	58.9	9.7	68.7	Number over 20 g body weight and mean percent	677	58.9	9.7	68.7

The place of capture showed a seasonal change from outdoors to indoors in both nonbreeding and breeding females during the monsoon months of July through September (Table 6). This may be due to the hardships that heavy rains would exert on females nesting outdoors and may or may not reflect an actual movement of breeding females into indoor habitats during the monsoon period. To a lesser degree, males were found indoors in greater proportion (but never a majority) during the monsoon months and the months immediately following.

Discussion

Suncus murinus is noted for the significant sexual dimorphism in body weight and body length, males being longer and heavier (Barbehenn 1962; Harrison 1955; Louch et al. 1966). Growth data provided by Dryden (1968) indicated that from about 20 days following birth, males tended to become heavier than females and continued to do so until at least 120 days old. We found, also, that at equivalent HBL's males were significantly heavier from 120 mm HBL and greater. Mean HBL's and weights of male *S. murinus* from Rangoon averaged 11.9 mm and 19.3 g, respectively, greater than those of females for the entire sample.

One difficulty in drawing comparisons between the several *S. murinus* populations that have been studied is the extreme variation in the adult weights of this species from different geographic localities. The heaviest *S. murinus* were reported from Calcutta by Louch et al. (1966) who found that male shrews averaged 105,6 g in weight and females, 67.6 g. The heaviest male weighed 177 g. The smallest *S. murinus* were recorded from Guam by Barbehenn (1962), who noted the mean weight of males to be 30 g (maximum 46 g) and that of females as 21 g (maximum 29 g). *Suncus murinus* from Rangoon are somewhat larger than those from Malaysia (Harrison 1955) but considerably smaller than those from Calcutta.

The unequal sex ratio in our sample was due partly to the same factor as suggested

Table 4

Monthly prevalence of pregnancy or lactation in S. murinus from Rangoon

Month	Total adult females examined[1]	No. pregnant	No. lactating	% pregnant or lactating
Jan.	59	34	3	62.7
Feb.	36	23	3	72.2
Mar.	74	44	7	68.9
Apr.	70	45	7	74.3
May	58	41	4	77.6
June	65	37	9	70.7
July	39	18	7	64,1
Aug.	47	26	4	63.8
Sept.	48	35	3	79.2
Oct.	71	35	9	62.0
Nov.	61	41	7	78.7
Dec.	49	20	3	46.9
Totals	677	399	66	68.7

[1] All females exceeding 100 mm head and body length or 20 g body weight.

Table 5

Litter size in relation to weight and length of female S. murinus

Female body weight g	Mean no. embryos ± S.D.	Female head and body length mm	Mean no. embryos ± S.D.
20–29	3.67 ± 0.8	100–109	2.81 ± 1.1
30–39	2.69 ± 1.0	110–119	2.79 ± 1.0
40–49	2.84 ± 1.2	120–129	2.89 ± 1.2
50–59	3.43 ± 1.2	130–139	3.42 ± 1.2
60–69	3.40 ± 1.4	140–	3.85 ± 1.7

by HARRISON (1955); i.e., the inefficiency of the traps for the samaller animals. A number of our live-capture traps were medofied in July 1976, by the addition of smaller aperture wire mesh. Prior to that date, in 8 months of trapping, we had captured a total of 95 male shrews, while only 11 females were taken. After modifying the traps in July, we captured 104 males and 80 females in the next 4 months. Even so, subsequent captures have still given an unequal number of 912 males to 670 females, or a ratio of 1 to 0.7. This ratio also differs significantly from equality ($\chi^2 = 37.0$; $P = .001$). These results may be due in part to the greater activity of males.

The size at sexual maturity in male *S. murinus* from the various geographic populations correlates well with the variations in body size of adults reported from the several areas. Calculations from DRYDEN's (1968, 1969) data on *S. murinus* from Guam approximate a 50% point of fertility in males of 22.0 g (about 45 days old). HASLER et al. (1975) confirmed in their work that the Guam stock of *S. murinus* first showed sperm in the epididymis at about the age of 45 days. HARRISON (1955) gave the 50% point for fertility (as judged by sperm in the epididymis) in males from Malaysia as 31.5 g and the 95% point as 46.1 g. The 50% point at sexual maturity of male *S. murinus* from Rangoon, based upon the evidence of macroscopically visible seminiferous tubules in the testes, was 44.5 g BW and the point at which all males showed evidence of fertility occurred at 52 g BW and 124 mm HBL.

The small seasonal fluctuation in testes weights as noted in Rangoon *Suncus* was also re-

Table 6

Prevalence of breeding activity in female Suncus by place of capture and by season
number captured

	Place of capture		
	Indoors	Outdoors	Totals
Pregnant or lactating	190	274	464
Not pregnant or lactating	109	107	216
Totals	299	381	680

	Season of capture				
	Winter	Spring	Summer	Fall	Totals
Active breeders					
Outdoors	76	86	43	69	274
Indoors	38	56	49	47	190
Non-breeders					
Outdoors	34	30	15	28	107
Indoors	22	23	26	38	109

ported by LOUCH et al. (1966) in Calcutta and HARRISON (1955) in Malaysia. The fluctuation in male fertility in the fall and winter does correlate somewhat with the prevalence of pregnancy in females, where a drop in prevalence occurs in the fall sample. The population size composition of the male shrews did not vary significantly with the seasons and therefore should not be a factor in the fluctuations of pregnancy and lactation in females.

The size of female *S. murinus* at sexual maturity shows a positive correlation to the body size of adults from the several geographic populations. HARRISON (1955) recorded 27 g as the smallest pregnant females seen in Malysia. DRYDEN (1969) reported that four captive *S. murinus* females bred as early as 30 days old and one at 36 days. All five females nursed and weaned their young. Using these ages and extrapolating from the growth data from DRYDEN's (1968) previous paper, breeding females could be discerned at about 17 or 18 g BW.

Table 7

Prevalence of pregnancy by seasons in Suncus murinus

	Percentage composition of seasonal sample					
	Jan.–Mar.	Apr.–June	Jul.–Sep.	Oct.–Dec.	Sample size	% Pregnant
Rangoon						
percent pregnant	60	63	57	54	679	59
Calcutaa						
percent pregnant	46	52	47	33	92	48
Guam						
percent pregnant	38	54	50	38	144	44
Malaya						
percent pregnant	25	19	22	42	290	24
Nagpur						
percent pregnant	65	75	52	25	75	52

We found pregnant females at a minimum of 20 g BW in Rangoon, but the 50% point for pregnancy was determined to be 32 g BW and 108 mm HBL. Barbehenn (1962) gives the lower limit of fertility in female shrews from Guam as 95 mm HBL or 19 g BW.

The seasonal changes in the prevalence of pregnancy observed in *Suncus murinus* females in Rangoon could be due to several factors. The pattern of pregnancy followed closely that observed in *Suncus* in Calcutta and Guam (Louch et al. 1966; Barbehenn 1962). Our data supports the hypothesis of Barbehenn (1962) that seasonal changes in reproduction are possibly associated with changes in rain-fall and that the peak of reproductive activity occurs after about three months of dry weather and declines after about three months of rainy weather. In Rangoon the peak of pregnancies occurred during and at the end of the dry season months of January through May and then declined as the rainy season set in. Our data indicated that more pregnant females were captured inside structures during the monsoon months (Table 6), and would support the contention that the monsoon rains exerted an effect upon the breeding females, possibly forcing many to abandon outdoor nesting habitat in favour of indoor nests.

Another factor of importance mentioned by Barbehenn (1962) was the seasonal changes observed within the population structure of breeding size females. In his samples from Guam, the larger females predominated in spring and summer and younger animals increased in proportion in the fall and were a majority in the winter sample. This high proportion of larger females correlated with the peak breeding effort. Our data from *Suncus* in Rangoon did not show this pattern in prevalence of pregnancy. We thus consider that the minor fluctuations in population structure we observed had little influence upon the prevalence of pregnancy. The possible effect of male fertility, as previously noted, may account for the sharp decline in pregnancies in December.

The level of breeding activity observed in *Suncus* populations in Rangoon is the highest yet reported for this species (Table 7). If the prevalence of pregnancy figures, as given in Table 4, are corrected to account for 26.7% of undetected pregnancies that could be assumed in the adult females classified as reproductively inactive, the estimated monthly figures for total breeding activity would range from 61.2% in December to 85.4% in September and the annual value would be 77.1%. This represents a remarkable reproductive effort, especially since it is maintained at such high levels virtually throughout the year. When Barbehenn's (1962) data are adjusted by dropping the smallest females (80 to 94 mm HBL) in which no visible pregnancies were seen, the data from Guam approach but do not exceed those we report.

This high prevalence of pregnancy in commensal small mammals has been seen in *Bandicota bengalensis, Rattus exulans* and *R. rattus* from Rangoon (Walton et al. 1978; Walton et al. 1979; Brooks et al. 1978). All urban commensal small mammals in Rangoon have populations at, or near, saturation densities and none have shown any significant fluctuations during the past three year's observations. Since the proportion of *Suncus* captured during this period has remained relatively constant, the question may be asked, how has *Suncus*, with its much smaller litter size, managed to hold its own in competition in relation to the rat species? The answer may lie partly in the fact that it shows the highest prevalence of visible pregnancy (58.9%) of any of the species studied, females are capable of breeding at 30 to 36 days of age (Dryden 1969), post partum breeding is common (about one-quarter of all pregnant females were lactating), and consequently, the average time between successive litters was 37 days.

When the annual production of young per female is calculated using the method of Emlen and Davis (1948), the number of litters per year for *Suncus* average 9.8 and the number of young produced equals 24.2. While this value is not as great as that of any of the rat species (*B. bengalensis*, 39.8 young per year; *R. rattus*, 37.9; and *R. exulans*, 35.6) in Rangoon, nevertheless it is enough for *Suncus* to maintain its place in the urban fauna. Other factors undoubtedly must influence population levels of shrews in a manner or degree different than

they do in the rodent species. *Suncus* may avoid direct competition with the rodents because it occupies a quite different ecological niche due to being a scavenging insectivore and a ground-surface dwelling animal. Other factors could contribute to a greater longevity; such things as breeding peaks at seasons other than when the rodent species are most active or differential survival of young during the immediate post-natal period due to a longer lactation and different behaviour when leaving the nest (e. g. „caravanning"). The combination of reproductive factors as reported here certainly contributes to the success of this insectivore in urban environments in the tropics. In Rangoon this species is second only to *B. bengalensis* in relative abundance and general distribution throughout the city.

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Zusammenfassung

Beobachtungen zur Fortpflanzungsbiologie von Suncus murinus L. in Rangun, Burma

Beobachtungen zur Fortpflanzungsbiologie von *Suncus murinus*, einer asiatischen Hausspitzmaus, ihre synanthropische Lebensweise als auch ihre Stellung in Beziehung zu verschiedenen anderen Muriden in Rangun, Birma, werden dargelegt. Männchen erreichten signifikant größere Länge und größeres Gewicht verglichen mit den Weibchen. Das maximale Gewicht für Männchen war 110 g, für nicht tragende Weibchen 80 g. Das Verhältnis der gefangenen Männchen im Vergleich mit den Weibchen war 1:0,7.

Alle Männchen waren fortpflanzungsfähig mit einem Körpergewicht von 52 g und einer Gesamtkörperlänge (ohne Schwanz) von 124 mm. Weibchen waren schon fortpflanzungsfähig, beurteilt nach sichtbaren Corpora lutea, sichtbarer Trächtigkeit oder Laktation, mit einem Körpergewicht von 20 g und 98 mm Gesamtkörperlänge. Eine 50% Häufigkeit für Trächtigkeit und/oder Laktation wurde berechnet für Körpergewicht mit 32 g und Gesamtkörperlänge mit 108 mm.

59% aller ausgewachsenen Weibchen waren sichtbar tragend, 10% laktierend; das ergibt eine Fortpflanzungsaktivität von 69%. 26% der tragenden Weibchen war auch laktierend, ein Hinweis, daß sie kurz nach der Geburt wieder tragend wurden. Die durchschnittliche Größe der Würfe betrug 2,99 ± 1,21 (S. A.). In den frühen Stadien der Trächtigkeit wurde eine durchschnittliche Wurfgröße von 3,34, in den späteren Stadien von 2,47 berechnet. Das läßt auf eine intrauterine Sterblichkeit von 0,87 Embryonen pro Wurf schließen. Die Wurfgröße 2,47 wurde benutzt um die Zahl der Jungen pro reproduzierendes Weibchen im Jahr zu berechnen, sie betrug 24,2.

Trächtigkeit wurde am häufigsten in den kühlen, trockenen Monaten, Januar bis März, und den heißen Übergangsmonaten zum Monsun, April bis Juni, beobachtet. Offensichtlich verursachen die Monsunregen die Reduzierung der Trächtigkeitsrate, und nur während der Monsunmonate wurden mehr tragende Weibchen in den Häusern als außerhalb gefangen.

Die asiatische Hausspitzmaus, *Suncus murinus*, erhält ihre Population im Vergleich mit den städtischen synanthropischen Ratten, obwohl sie eine längere Tragezeit und kleinere Würfe hat. Sie kann dies, da sie häufiger tragend wird, früher tragend wird und eine hohe Konzeptionsrate kurz nach der Geburt hat, und somit den Abstand zwischen Trächtigkeiten verringert.

References

Barbehenn, K. R. (1962): The house shrew on Guam. In: Pacific Island Rat Ecology. Ed. by T. I. Storer. Bishop Mus. **225**, 247–256.

— (1974): Recent invasions of Micronesia by small mammals. Micronesica **10**, 41–50.

Boshell-M, J.; Rajagopalan, P. K.; Goverdhan, M. K.; Pavri, K. M. (1968): The isolation of Kyasanur Forest Disease virus from small mammals of the Sagar-Sorab Forests, Mysore State, India: 1961–1964. Indian J. Med. Res. **56**, 569–572.

Brooks, J. E.; U Hla Naing; Walton, D. W.; Daw San Myint; U Maung Maung Tun; U Thaung; Daw Ohn Kyi (1977): Plague in small mammals and humans in Rangoon, Burma. Southeast Asian J. Trop. Med. Publ. Hlth. **8**, 335–344.

Brooks, J. E.; Walton, D. W.; U Hla Naing; U Maung Maung Tun; Pe Than Htun (1978): Some observations on reproduction in *Rattus rattus* (L.) in Rangoon, Burma. Z. Säugetierkunde **43**, 203–210.

Cavanaugh, D. C.; Dangerfield, H. G.; Hunter, D. H.; Joy, R. J. T.; Marshall, Jr., J. D.; Quy, D. V.; Vivona, S.; Winter, P. E. (1968): Some observations of the current plague outbreak in the Republic of Vietnam. Am. J. Publ. Hlth. **58**, 742–752.

Deshpande, K. S. (1959): Morphology of the male reproductive system in the shrew, *Suncus murinus* Linn. (Insectivore, Soricidae). Bull. Zool. Soc. Coll. Sci. (Nagpur) **2**, 1–9.

Deshpande, K. S. (1960): Breeding season in the common Indian musk-shrew, *Suncus murinus* Linn. in Nagpur. Bull. Zool. Soc. Coll. Sci. Nagpur, India, **3**,73–77.

DeVos, A.; Manville, R. H.; Van Gelder, R. G. (1956): Introduced Mammals and their influence on native biota. Zoologica **41**, 163–194.

Dryden, G. L. (1968): Growth and development of *Suncus murinus* in captivity in Guam. J. Mammalogy **49**, 51–61.

Dryden, G. L. (1969): Reproduction in *Suncus murinus*. J. Reprod. Fert., Suppl. **6**, 377–396.

Ellerman, J. R.; Morrison-Scott, T. S. C. (1966): Checklist of Palaeartic and Indian Mammals, 1758–1946. London: British Museum (Natural History).

Emlen, J. T. Jr.; Davis, D. E. (1948): Determination of reproductive rates in rat populations by examination of carcasses. Physio. Zool. **21**, 59–65.

Harrison, J. L. (1955): Data on the reproduction of some Malayan mammals. Proc. Zool. Soc. London **125**, 445–460.

Harrison, J. L. (1974): An Introduction to Mammals of Singapore and Malaya. 2nd Ed. Singapore: Malayan Nature Society.

Hasler, M. J.; Falvo, R. E.; Nalbandov, A. V. (1975): Testicular development and testosterone concentrations in the testis and plasma of young male shrews (*Suncus murinus*). Gen. Comp. Endocrin. **25**, 36–41.

Hasler, M. J.; Hasler, J. F.; Nalbandov, A. V. (1977): Comparative breeding biology of musk shrews (*Suncus murinus*) from Guam and Madagascar. J. Mammalogy **58**, 285–290.

Kundin, W. D.; Carlos, E. R.; Tsai, C. C.; Kueczynski, G. A. (1970): *Suncus* as a potential reservoir of leptospirosis: the blaming of the shrew. Southeast Asian J. Trop. Med. Publ. Hlth. **1**, 270–274.

Louch, C. D.; Ghosh, A. K.; Pal, B. C. (1966): Seasonal changes in weight and reproductive activity of *Suncus murinus* in West Bengal, India. J. Mammalogy **47**, 73–78.

Marshall, J. D.; Quy, D. V.; Gibson, F. L.; Dung, T. C.; Cavanaugh, D. C. (1967): Ecology of Plague in Vietnam. I. Role of *Suncus murinus*. Proc. Soc. Exp. Biol. Med. **124**, 1083–1086.

McNeill, D.; Jenkin, H.; Armstrong, D.; Chang, Y. S.; Liem, J. C.; Meyer, K. F. (1968): A serological survey of rodent plague in Taiwan and offshore islands. W. H. O. Bull. **38**, 793–798.

Peenen, P. F. D. Van; Light, R. H.; Sulianti Saroso, J. (1971): Leptospirosis in wild mammals of Indonesia – Recent Surveys. Southeast Asian J. Trop. Med. Publ. Hlth. **2**, 496–502.

Smith, G. C. E.; Turner, L. H.; Harrison, J. L.; Broom, J. C. (1961): Animal leptospirosis in Malaya. I. Methods, Zoogeographical background, and broad analysis of results; II. Localities sampled; III. Incidence in rats by sex, weight and age. W. H. O. Bull. **24**, 5–21, 23–34, 807–816.

Walton, D. W.; Tun, M. M. (1978): Fleas of small mammals from Rangoon, Burma. Southeast Asian J. Trop. Med. Publ. Hlth. **9**, 369–377.

Walton, D. W.; Brooks, J. E.; Tun, M. M.; Naing H. (1978): Observations on reproductive activity among female *Bandicota bengalensis* in Rangoon. Acta Theriol. **23**, 489–501.

Walton, D. W.; Brooks, J. E.; Thinn, K. K.; Tun, M. M. (1979): Reproduction in *Rattus exulans* in Rangoon, Burma. Mammalia. (in press).

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